ARGENTINA'S LOST DECADE AND SUBSEQUENT RECOVERY:

HITS AND MISSES OF THE NEOCLASSICAL GROWTH MODEL*

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Abstract

We examine the economic depression that Argentina suffered in the 1980s, as well as the subsequent recovery, from the perspective of growth theory, taking total factor productivity as exogenous. The predictions of the neoclassical growth model conform rather well with the evidence for the "lost decade" depression and at the same time point to a puzzle: Investment did not recover in the subsequent decade of the 1990s nearly as fast as it should have according to that same model.

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1. INTRODUCTION

The unusual features and severity of the Great Depression in the United States have been the object of much speculation among economists and social scientists intrigued by a phenomenon still resistant to a widely accepted explanation. Lack of progress in understanding the Great Depression may be attributed, at least in part, to the unavoidable limitations of the "event study" methodology with which most scholars have approached the "case," possibly out of the perception that the Great Depression was an episode so rare that it is the only experience with depressions available for study in actual economies.

In addition, implicit in that case study approach to the Great Depression is often the view that depressions are not just rare in frequency, but also in nature. That is, they represent an essential "discontinuity" with the past and the future, perhaps because, for reasons not fully understood, the behavior that economic agents typically display in normal times is suspended, as it were, during economic depressions and replaced with a different one. The difficulty with this view is that the very rarity of depressions conspires against the ability to identify which elements, if any, of the economic environment or agents' behavior and expectations during economic depressions are substantially different, to the point of discontinuity, from more normal times.

That is an unfortunate state of affairs, because protracted and severe depressions are not as rare as many scholars seem inclined to believe. In fact, this paper has been motivated by the evidence that not long ago, during the 1980s (the so-called "lost decade"), Argentina experienced a rather severe economic depression as defined in this volume:[1] Detrended output per working age population declined along that decade a stunning 30 percent and it was 20 percent below trend by the time the decade was over.

Faced with this evidence, it is only natural to ask: Can standard growth theory account for the economic depression of Argentina's lost decade? In this chapter we answer this question in the affirmative: Our numerical experiments for a parsimonious neoclassical growth model that takes Total Factor Productivity (TFP hereafter) as exogenous generates paths for real GDP per capita, capital input, and the capital–output ratio that are strikingly close to the actual paths of those variables during the lost decade.

[1] See introductory chapter by Kehoe and Prescott in this same volume.

We interpret those findings as evidence that economic depressions are not necessarily associated with any abnormal deviations or discontinuity in the formation of expectations or in the behavior of economic agents from normal times.

Somewhat surprisingly, the paper uncovers that if there was any abnormal or discontinuous behavior in the light of the neoclassical growth model, it was not during the depression years of the lost decade but in the subsequent recovery: capital accumulation during the expansion of the 1990s proceeded at a lower rate than the same neoclassical growth model would have predicted. We conjecture that accounting for this anomaly might be as important for the understanding of Argentina's growth experience as it is to account for that country's lost decade years. Furthermore, since Cole and Ohanian (1999) report a similar "success" of the neoclassical growth model to account for the U.S. Great Depression and a similar "failure" to account for the recovery that followed, the resolution of the "1990s puzzle" for Argentina may have potentially important implications for growth theory in general and, as such, is an interesting research topic in its own right.

It is important to emphasize that it was precisely to be able to uncover regularities across countries like the one just reported for the United States and Argentina that this chapter, in the spirit of this volume, examines Argentina's growth experience during the depression of the 1980s and the recovery of the 1990s exclusively through the lens of the neoclassical growth model. In so doing, we do not imply that the neoclassical growth model is the only relevant one for the study of economic depressions. Rather, the hope is that studying economic depressions (and subsequent recoveries) with that same model across countries might lead to insights into the nature of depressions and of economic growth in general that would not be possible with the limitations inherent to the event study approach mentioned earlier.

A quick summary of our methodology is as follows: We compute the total factor productivity (TFP) time series (Solow residuals) of a typical constant-returns-to-scale production function with standard growth accounting methods and calibrate a parsimonious neoclassical growth model to the Argentine economy during "normal times," or more rigorously speaking, to its implied steady state. We then compute the economic agents' decision rules under the assumption of rational expectations and feed the measured Solow residuals into the model economy to generate the paths for real GDP per capita, capital stock, and employment (number of workers) induced by those decision rules. The comparison of the model-generated path for each variable with the actual data for the same variable makes it possible to infer which fraction of the year-to-year variations of such variables during the lost decade years and subsequent recovery can be accounted for by the actually observed TFP shocks.

2. OVERVIEW OF THE ARGENTINE GROWTH EXPERIENCE

Figure 1 offers a quick overview of Argentina's economic growth in the second half of the 20th century. It plots an index of real GDP per working-age person from 1950 to 1997, detrended by the average growth rate of the labor augmenting technological progress (the TFP factor) for the period 1951–79 (1.03 percent). This choice will be more thoroughly justified later, in the section of the paper devoted to the calibration of the model economy to Argentina's long-run growth features.

According to Figure 1 and as anticipated in the introduction, by the end of the lost decade, in 1990, Argentina's detrended GDP per capita had fallen a striking 30 percent below its level of ten years earlier and 20 percent below trend.

To identify the sources of growth, we undertook a growth accounting exercise. Appendix A outlines our data sources and the method we used in constructing these series.

In our growth accounting exercise, we assume that the production function is given by

$$Y_t = A_t K_t^{\theta} L_t^{1-\theta} \tag{1}$$

where Y is aggregate output, A is TFP, K is aggregate capital, and L is aggregate employment.

Our growth accounting differs in appearance, but is equivalent to standard growth accounting. We decompose output per capita into three factors: the TFP factor $A^{1/(1-\theta)}$, employment intensity (L), and the capital intensity factor $(K/Y)^{\theta/(1-\theta)}$. This decomposition is convenient because the growth rate of the efficiency factor coincides with the trend growth rate of output per adult when employment per capita and capital intensity are constant, as they should be along the balanced-growth path.[2]

Table 1 presents the results of our growth accounting exercise for a capital share of 0.4 (see our discussion below on calibration).

From 1951 to 1979, GDP per working-age person grew at a 1.7 percent annual rate. TFP and capital intensity contributed about equally to that growth, while employment intensity subtracted about 0.2 percentage points from it. Within this period, the 1960s stand out for rapid 3 percent GDP growth, accounted almost entirely by productivity gains. The 1950s and 1970s, on the other hand, reveal capital intensity as the only factor making significant positive contributions to GDP growth in those two decades, when TFP exhibited a relatively poor performance, in particular in the 1970s, during which it declined at an average annual rate of 0.14 percent.[3]

The observation that capital intensity grew at annual rates slightly below 1 percent in the whole period 1951–79 suggests that Argentina may not have been growing along its balanced growth path then, but that it was rather in the process of converging to the higher income per capita of more developed nations. The possible presence of transition dynamics over this period had implications for the calibration of the capital–output ratio, as discussed later in the appropriate section of the paper.

The mild decline of TFP during the 1970s already reported turned into an unprecedented collapse in the subsequent lost decade of the 1980s, during which the TFP factor fell at an average rate of almost 3 percent a year, that is, at about the same rate at which it had increased instead during the 1960s.[4] This collapse of productivity, moderated by mild increases in labor and capital intensity, more than accounted for the 2.1 percent average annual decline in GDP per capita during that depression.

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[2] As explained in the introductory chapter of this volume, this "intensive" version of an otherwise standard growth accounting exercise is obtained by first multiplying both sides of the production function (1) by $N^{(\forall - 1)}/Y^{\forall}$ and then solving the resulting expression for GDP per capita.

[3] Recall that the gross TFP factor is equal to $(1 + ()$, which implies that total factor productivity, as calculated from $(1 + ()^{(1 - 2)} = (1 - 0.0024)^{(1 - 0.4)}$, declined at an average annual of 0.14 percent in the period 1969–79.

[4] By the arithmetic of the previous footnote, this explains an average annual total factor productivity decline of around 1.75 percent for the lost decade.

The rather dramatic decline of TFP during the lost decade was followed by an impressive turnaround in the subsequent 1990–97 period. Output per capita grew at average rates 2.5 times higher than for the period 1951–79. This growth was driven by an unprecedented 7 percent growth in TFP, partially offset by a rather deep decline in the capital intensity that hints at the "1990s excessive capital-shallowing puzzle" that, as reported below, we regard as one of the relevant findings of this study.

Summing up, according to our growth accounting exercise, TFP seems to have been the dominant force behind Argentina's growth performance in the two decades that closed the last century. This feature of Argentina's recent growth experience, along with the observation that the neoclassical growth model takes TFP as exogenous, leads naturally to the question addressed in this paper: Which percentage of the growth rates of the main macroeconomic variables (GDP, capital stock, employment) during those two decades can such a neoclassical growth model account for if subject to the same productivity shocks measured for Argentina over those same periods? The next section presents the tools and measures with which we'll attempt to answer that question.

3. ANALYTIC FRAMEWORK

Model

We use the stochastic growth model. All variables are in per capita terms. Household preferences can be represented by:

$$E \sum_{t=0}^{\infty} \beta^t (1+\eta)^t \ (c_t^{\alpha} (1-l_t)^{1-\alpha})^{1-\sigma} /(1-\sigma) \tag{2}$$

where c_t represents consumption, l_t the fraction of the time endowment devoted to work, α the utility-function share parameter, η the population growth rate, and σ the coefficient of constant relative risk aversion (or the reciprocal of the intertemporal elasticity of substitution of the composite commodity).

Technology is described by

$$c_t + x_t = z_t \, k_t^{\theta} \, [(1+\gamma)^t l_t]^{1-\theta} \tag{3}$$

$$x_t = (1+\gamma)(1+\eta)k_{t+1} - (1-\delta)k_t \qquad (4)$$

$$z_{t+1} = \rho z_t + \varepsilon_t \qquad (5)$$

where k_t is the capital stock, x_t is investment, z_t a stochastic technological shock, and θ the capital input share in national income. The model assumes labor augmenting technological progress at the rate γ. On the balanced growth path, output, consumption and capital grow at the rate $(1 + \eta)(1 + \gamma)$.

Calibration

The model economy is calibrated by choosing parameters so that the balanced growth path matches certain steady-state features of the measured economies (see Cooley and Prescott 1995).

We chose the period 1951–79 to establish the long run features of Argentina's growth rather than the whole period for which the relevant data are available (1951–97) because, in the spirit of calibration, the period 1951–79 does not include any of the observations corresponding to the two decades that are the object of study in this paper. That is, we calibrate Argentina's economy to its long run features as revealed by the information available to the economic agents by 1979 and ask whether a neoclassical growth model thus calibrated can account reasonably well for Argentina's relevant growth features afterwards, during the lost decade and subsequent recovery of the 1990s.

Consistent with that choice of reference period, the following parameters (with their actual values in parentheses) were set to their average value over 1951–79: annual growth rate of working-age population (1.55 percent), labor augmenting technological progress (TFP factor, 1.03 percent), and the investment–output ratio (0.226).

It would be tempting to set the average capital–output ratio to its average over that period as well. However, unlike with the average TFP growth, this procedure is likely to underestimate the underlying long-run capital–output ratio if in the reference period the economy is not on the balanced growth path, but converging to it from "above" or "below." As per the evidence discussed in the previous section, the latter seems to have been the case for Argentina during the reference period. Accordingly, the underlying long-run capital–output ratio is likely to be closer in magnitude to the ratios actually observed toward the end of that period than to their average over that same period. Given that the observed capital–output ratio for Argentina was still in an upward trend by the time it reached values of around 1.9 in 1978 and 1979, we adopted 2 as a reasonable guess for the value of that ratio in the long run.[5]

That calibrated capital–output ratio, along with the investment-output share of 0.226 calibrated earlier, implies a depreciation rate of about 11.3 percent, via the standard neoclassical growth model steady state relationship $\delta = (x/y)/(k/y)$. This depreciation rate abstracts from total factor productivity growth and population growth because the model economy used for the numerical experiments assumes no growth. Hansen (1997) has shown that this way of calibrating the depreciation rate ensures a better correspondence between the series generated by the model and the actual data of an economy with growth.

Another parameter that is particularly challenging to calibrate for the case of Argentina is the capital share parameter θ of the production function. The national income accounts typically used to that effect in countries like the United States are not available in Argentina, which can therefore estimate its GDP only from the product accounts. As a result, the labor and capital cost shares in GDP cannot be calculated directly from reported factor incomes. Therefore, we set the capital input share, θ, to 0.40, as if Argentina's production technology were the same as that of the United States. While some estimates have the capital share at 60 percent of GDP, most researchers consider that this figure would be closer to 40 percent were it not for the substantial underreporting of labor income in the informal sector of Argentina's economy.[6]

The steady-state real interest rate was set equal to 8.7 percent, as implied by the steady-state relationship $r = \theta Y/K - \delta$ (again, abstracting for the reasons previously given from long-run growth rates).

The utility-function share parameter, α, was set to imply that the average household member spends a fraction 0.3 of its time endowment in the labor market, a

[5] However, sensitivity analysis suggests that the results are quite sensitive to the choice of this value.
[6] De Gregorio and Lee (1999) find that the labor share could be as large as 0.7, according to the indirect measure proposed by Sarel (1997).

standard assumption for the United States that casual inspection of the available data suggests reasonable for Argentina as well.

The coefficient of constant relative risk aversion was set at the level used in similar studies for the United States, that is, $\sigma = 2$.

Finally, the persistence parameter ρ, the autoregressive component of the total factor productivity shock, was established from an autoregression on the Solow residuals (TFP) computed in the previous section of the paper for the period 1951–79, and set, accordingly, equal to 0.56. The innovation (ε_t) is assumed to be an i.i.d. process with mean zero and standard deviation $1/(1-\rho)^2$.

Computation

In our numerical experiments, we exploit the second welfare theorem to compute the solution of a dynamic stochastic general equilibrium neoclassical growth model. Since $\sigma > 1$, $0 \leq \alpha \leq 1$ and $0 \leq \theta \leq 1$, the conditions for the second welfare theorem hold. In particular, the utility function is concave, and the production function defines a convex set for the resource constraint. This will guarantee that the solution to the social planner's problem can be decentralized as a competitive equilibrium. Notice that this problem is a version of the stochastic growth model first developed by Brock and Mirman (1972).

Our strategy to compute the only solution of the model is to find the value function and associated policy (or allocation) functions. Following Kydland and Prescott (1982), we substitute the resource constraint in the utility function and rewrite the resulting expression as a quadratic approximation around the steady state. This defines a linear quadratic problem with well-known properties. In particular, the policy (or allocation) functions are linear in the state variables and can be readily computed with standard numerical methods (see Hansen and Prescott 1995).

Following the standard convention in that approach, the policy functions and resulting allocations are computed under the assumption that economic agents form expectations about the future rationally, based on the information available at the beginning of each period. This is in contrast with other papers in this same volume that assume perfect foresight.

For that reason, and in the spirit of facilitating comparisons across countries that inspires this volume, we report in Appendix B the results for our simulations under the alternative but unrealistic assumption of perfect foresight. Here it suffices to mention that under this alternative assumption some of our numerical experiments generated outcomes that differed from their stochastic counterparts in quantitatively significant ways. Such discrepancies might serve as a warning that considerable caution should be exercised in drawing conclusions from a perfect foresight model for volatile economies, subject to the same kind of wild depression and boom swings that Argentina experienced in the two decades studied here.

4. EXPERIMENTS

Purpose

In this section, we ask what fraction of the growth rates of the relevant economic variables during the lost decade and subsequent recovery can be accounted for by a stochastic neoclassical growth model in which exogenous shocks to TFP are the only source of uncertainty. To that effect, as indicated in the previous section, we compute the equilibrium decision rules and simulate the path of the relevant variables of the model by feeding the measured TFP into the equilibrium decision rules.

Findings

As Figure 2 makes apparent, the growth model with TFP taken as exogenous can account with remarkable precision for the dynamics of capital accumulation during Argentina's lost decade. Visual inspection of that figure, where the data, as in all subsequent figures, have been detrended by the TFP factor and working-age population growth, suggests that according to our numerical experiments, measured productivity can account for all of the decline in the capital stock during that depression.

However, Figure 3 reveals that the performance of the model is not as stellar with respect to labor input, especially in the second half of the depression. According to the model, labor input should have declined at an average annual rate of about 0.8 percent between 1984 and 1990, instead of increasing at that rate, as the data show.

Despite missing a non-negligible fraction of the dynamics of the labor input, the neoclassical growth model predicts capital input so precisely that overall TFP can account for practically all the decline in GDP during the lost decade, as shown in Figure 4. By the same token, TFP accounted for almost all of the variations in the capital–output ratio over that same period (Figure 5).

Overall, the results of the numerical experiments suggest that an economic agent equipped at the onset of the lost decade with the neoclassical growth model and knowledge of the sequence of the TFP exogenous shocks that would hit the economy from then on would have been able to pick up remarkably well the dynamic paths of the capital stock, GDP, and capital–output ratio during that depression. The same observer, on the other hand, would have missed the direction of change of labor input between 1984 and 1990, with the gap between observed and predicted values as large as 10 percent toward the end of the lost decade.

Perhaps somewhat surprisingly, inspection of Figure 4 suggests that whereas the neoclassical growth seems to be able to account for the lost decade depression rather easily, the same is not the case for the expansion that followed.

Indeed, according to Figure 4, output during the recovery of the 1990s should have grown at a rate two-thirds faster than it actually did. This prediction is a natural consequence of the overestimation over that period of the capital stock, which according to the model should have been about 15 percent higher than it actually was in the last year of that expansion, as shown in Figure 2. The resulting "1990s excess capital shallowing puzzle," reflected in a lower than predicted capital–output ratio and first discussed in Kydland and Zarazaga (2002b), is apparent also in Figure 5. On the other hand, the model captures well the general upward trend in labor input during the expansion, with any discrepancies between predicted and observed values never exceeding 5 percent, half the size of the equivalent discrepancies during the lost decade.

In other words, the neoclassical growth model fails during the expansion years where it succeeds during the depression years, and vice versa. During the lost decade depression, the neoclassical growth model accounts extremely well for the evolution of capital input, although it underestimates labor input to a considerable extent. During the expansion, these results are reversed: The neoclassical model accounts rather well for labor input, but it overestimates capital input instead.

The apparent “failure” of the neoclassical growth model to account for the expansion following a recession doesn’t seem to be unique to Argentina. As mentioned in the introduction, Cole and Ohanian (1999) report a similar result for the United States. Thus, perhaps somewhat surprisingly, taken together these findings suggest that the relevant question for future research might be not so much whether the neoclassical growth model can account for depressions, but for booms. A resolution of the “1990s puzzle” for Argentina could therefore have important implications for growth theory in general.

In the next section, we offer some conjectures that might help to explain the two “misses” of the neoclassical growth model reported above, that is, the underestimation of labor input during the lost decade and the overestimation of capital input during the subsequent expansion.

5. CONJECTURES FOR THE RESOLUTION OF THE ANOMALIES

The Lost Decade Excessive Employment Growth: The Employment Policies Conjecture

We found in our experiment that the model predicted that labor input should have declined overall by about 10 percent during the lost decade, while in the data measured labor input actually increased by 3 percent. We conjecture that government policy in Argentina might help explain this anomaly.

It has often been claimed that employment in provincial governments and state-owned enterprises in Argentina has been a covert form of unemployment insurance. Argentina was a heavily regulated economy until 1990, and it is well known that “payroll-credited” unemployment insurance payments are the common device through which centrally planned economies can artificially increase employment or reduce measured unemployment.

Until recently, the information in the household surveys did not distinguish employment in the private and public sectors. This deficiency cannot be solved with data from other sources, because information on employment in the public sector is virtually nonexistent. The official statistics report systematic information on government employment only for the central administration, and even so, they do not always include contract personnel that usually fluctuate more than the permanent staff.

There is, however, some indirect evidence that suggests the magnitude of government employment programs. Information on the number of workers employed by provincial administrations from nonofficial sources, such as in Chisari *et al*. (1993), suggests that employment at the provincial and national administration levels may have represented between 10 and 13 percent of the total number of workers in the period of analysis. However, this figure does not include employment in the vast number of state-owned enterprises that were still under government control during the lost decade. There are no official records of the number of workers employed in those government conglomerates. One way to establish a rough upper bound for that figure is to assume that all the increase in unemployment between the end of 1990 and 1995 corresponded exactly to the number of workers who lost their "hidden unemployment" when their firms were transferred to the private sector during the large-scale privatization process implemented over those years. Under that extreme assumption, the total number of workers in the public sector during the lost decade may have been on the order of 20 to 25 percent of total employment.

That fraction of total employment is not negligible and strongly suggests that government job programs may help explain why employment didn't decline during the lost decade, as predicted by the neoclassical growth model, but increased instead.

The policy implicit in those programs may have been to keep the job creation process going at a time when adverse and repeated productivity shocks would have led to a decline in overall employment. That is, negative productivity shocks like the ones observed in the lost decade in Argentina are typically associated with declines in real wages and therefore, employment, as households devote a larger share of their time to leisure or nonmarket activities. The conjecture entertained here is that the government prevented this outcome through job creation initiatives that kept real wages above the marginal product of labor. Faced with this artificially high opportunity cost of leisure, a larger fraction of the population than otherwise chose to seek employment or remained employed in the sectors of the economy favored with explicit or implicit employment subsidies, mainly government agencies and conglomerates.

The appalling state of disarray of the public finances throughout the lost decade is consistent with that hypothesis. By all accounts, bloated public sector payrolls were a major contributor to the large fiscal deficits observed throughout that decade, ultimately responsible for the hyperinflationary outbursts of 1989 and 1990.

This conjecture is not without its challenges, because the introduction of employment subsidies will require the explicit introduction of the government budget constraint into the analysis. A more rigorous assessment of the ability of this government jobs programs hypothesis to explain away the excessive labor input anomaly of the lost decade will need first to measure the size of those programs and then quantify the effects on capital and labor inputs of the taxes needed to finance them. Collecting the necessary data to calibrate taxes, subsidies, and other relevant aspects of the job creation programs might prove a difficult but worthwhile research effort.

The Excessive Capital-Shallowing Puzzle of the 1990s: The Capital Taxation Conjecture

As with the labor input growth anomaly of the lost decade just discussed, we conjecture that the excessive capital-shallowing anomaly of the 1990s can eventually be explained away by government policies as well—in particular, government policies that directly or indirectly penalized the accumulation of capital.

One possibility is that after the 1980s Argentina switched to a regime of higher capital taxes. This conjecture is motivated by the recurrent episodes of bank deposit confiscations and sovereign debt defaults that Argentina has experienced in the last twenty years, the latest such episodes very recently, in 2001.

Higher taxes on capital are associated, of course, with a lower long-run capital–output ratio, while the model in this paper maintains that ratio unchanged at 2. Given the low levels of that ratio at the end of the lost decade, the model induces a strong bounce-back effect of capital input during the positive productivity shock years of the 1990s. But that effect would be dampened, more in line with the data, if taxes on capital or equivalent policies implemented over the two decades studied in this paper had reduced the long-run capital–output ratio below the calibrated value of 2. Notice that this conjecture is consistent with the previous one: Taxes on capital are a good candidate to have been the source of funds to finance the job creation programs that might have been in place in the lost decade.

A related conjecture is based on the possibility of endogenous credit constraints of the type discussed in Kehoe and Levine (2001) and Alvarez and Jermann (2000). A growing body of literature suggests that small open economies face borrowing constraints that are binding not as much during downturns but during expansions (see, for example, Kehoe and Perri 2002). The reason for that counterintuitive outcome is that lenders do not have much interest anyway in investing in a country undergoing a period of low or declining productivity growth. By contrast, capital owners would like to invest a lot during a period of high productivity growth. The presence of default risk reduces their incentives to do so, however, because investors realize that it is at good times, after it has been able to lure capital into the country, that its governments will have the highest incentives to increase taxes on capital, perhaps to the point of confiscation.

Thus, a possible explanation of why investment remained so weak (relative to the model) in Argentina during the 1990s is that potential investors, their memories of that country's sovereign debt default in the mid-1980s and confiscation of deposits in 1990 still fresh, remained wary of similar episodes in the future and, accordingly, didn't risk their capital in Argentina as much as the neoclassical growth model would predict. Indeed, those fears have materialized recently, when in 2001 Argentina implemented the largest confiscation of deposits in its history and then proceeded to declare a massive default on its sovereign debt obligations.

Exploring the extent to which this "risk of default" conjecture can resolve Argentina's excess capital-shallowing puzzle of the 1990s will eventually require considerable departures from the default-free world of the neoclassical growth model, a task that poses challenging theoretical and empirical issues that should be part of the exciting research program we hope this paper will inspire.

6. CONCLUSION

This paper has explored the quantitative predictions of a rather parsimonious neoclassical growth model economy relative to the actual economy. Overall, our findings suggest that neoclassical growth theory can account for a great deal of Argentina's economic depression during the lost decade of the 1980s. In that regard, the evidence does not seem to provide support for the hypothesis that economic depressions involve a breakdown or discontinuity in the behavior of economic agents or in the way they form expectations about the future.

Instead, we uncover a puzzle in the recovery that followed the depression. According to the neoclassical growth model, the capital stock should have ended up about 15 percent higher in the last recorded year of the expansion of the 1990s, while in the data (detrended) that stock remained flat instead throughout the whole expansion. Given a similar failure of the neoclassical growth model to account for the recovery that immediately followed the U.S. Great Depression, as reported in Cole and Ohanian (1999), we regard this capital-shallowing puzzle of the 1990s as potentially the most interesting finding of this study and conjecture that accounting for it could prove a challenging task with important implications for growth theory.

The most puzzling aspect of the evidence, however, is why total factor productivity declined at an average rate of almost 3 percent for the unusually long time of a decade, the lost decade of the 1980s, and why it recovered so spectacularly at annual average rates of 7 percent in the subsequent expansion of the 1990s. It would be tempting to link those wild swings in productivity to the distinctive policy regimes in place in those two periods: a heavily regulated and closed economy in default in the lost decade, a more open, less regulated economy engaged in ambitious privatization programs in the 1990s. However, such a relationship is not warranted by the maintained hypothesis in this paper of exogenous productivity shocks. Any progress in establishing such a link (perhaps along the lines of Parente and Prescott 1999) will undoubtedly constitute a huge step forward in the understanding of the ultimate determinants of the prosperity of nations.

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Table 1
Accounting for Growth:

Time period	GDP per working adult (percent)	Factor (percent)		
		TFP factor	Capital intensity	Employment intensity
1951–59	0.47	0.19	1.30	–1.00
1959–69	3.01	3.02	–0.04	0.03
1969–79	1.51	–0.24	1.53	0.23
1951-79	1.74	1.03	0.90	-0.19
1979–90	–2.10	–2.90	0.48	0.34
1990–97	4.46	7.28	–2.87	0.25
1979-97	0.40	0.94	-0.83	0.30
1951-97	1.21	0.99	0.22	0

Figure 1
Detrended GDP per working age population

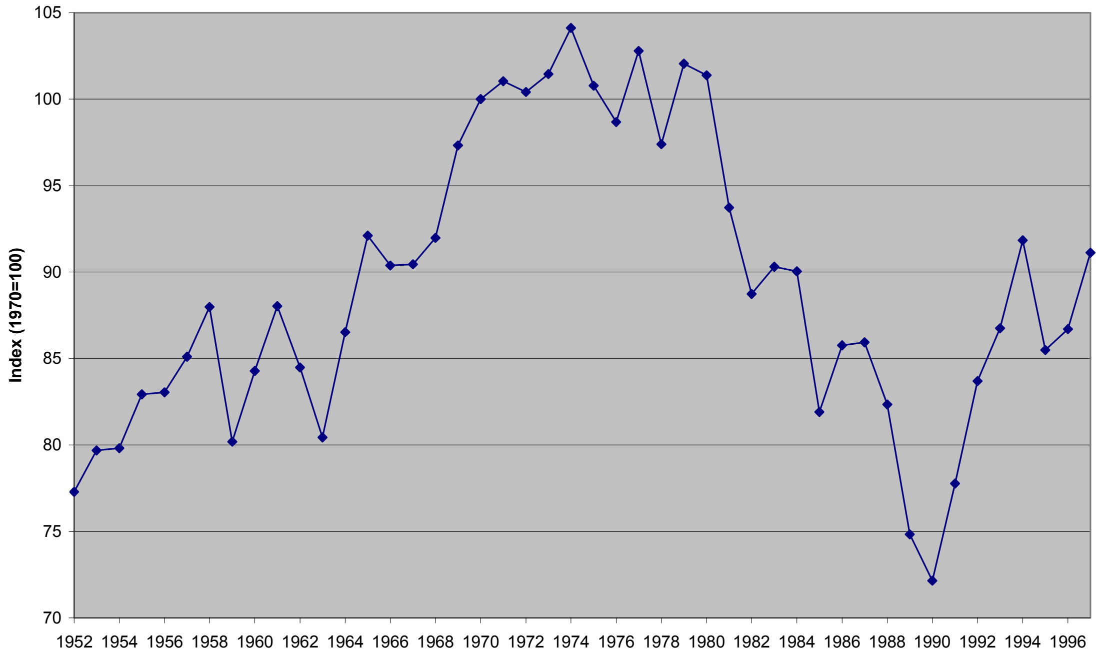


Figure 2
Capital Stock

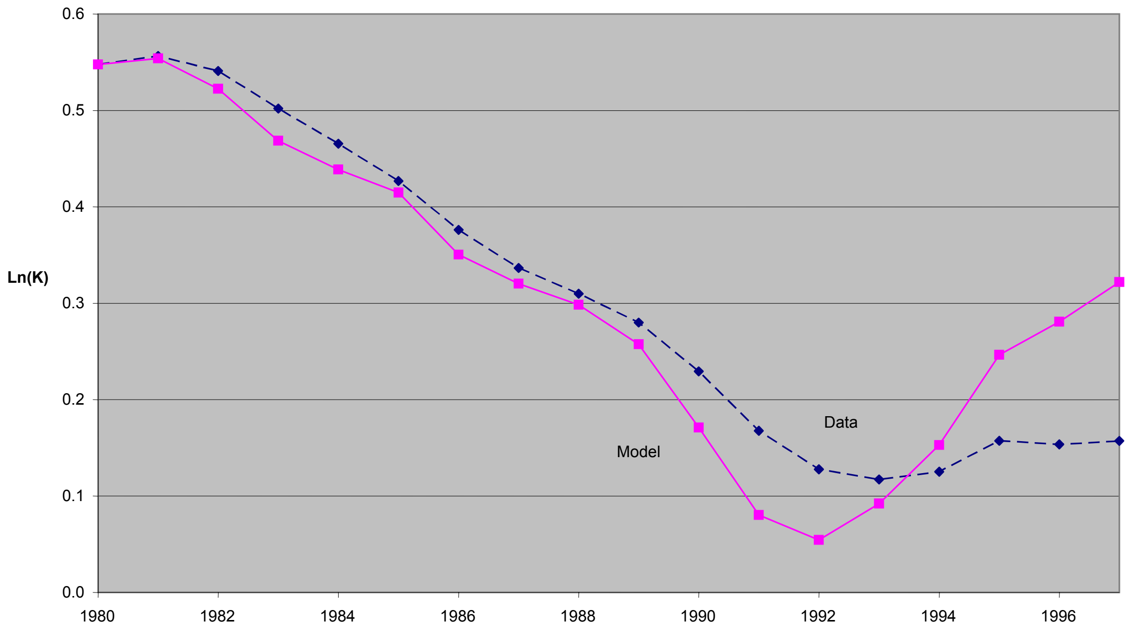


Figure 3
Labor Input

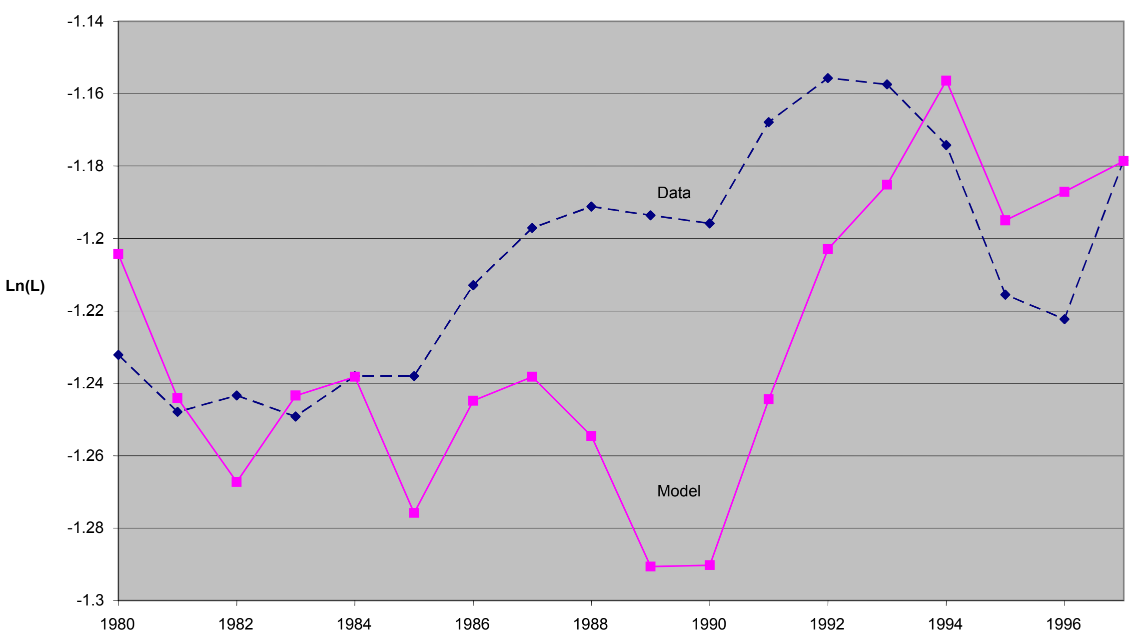


Figure 4
GDP per Working-Age Person

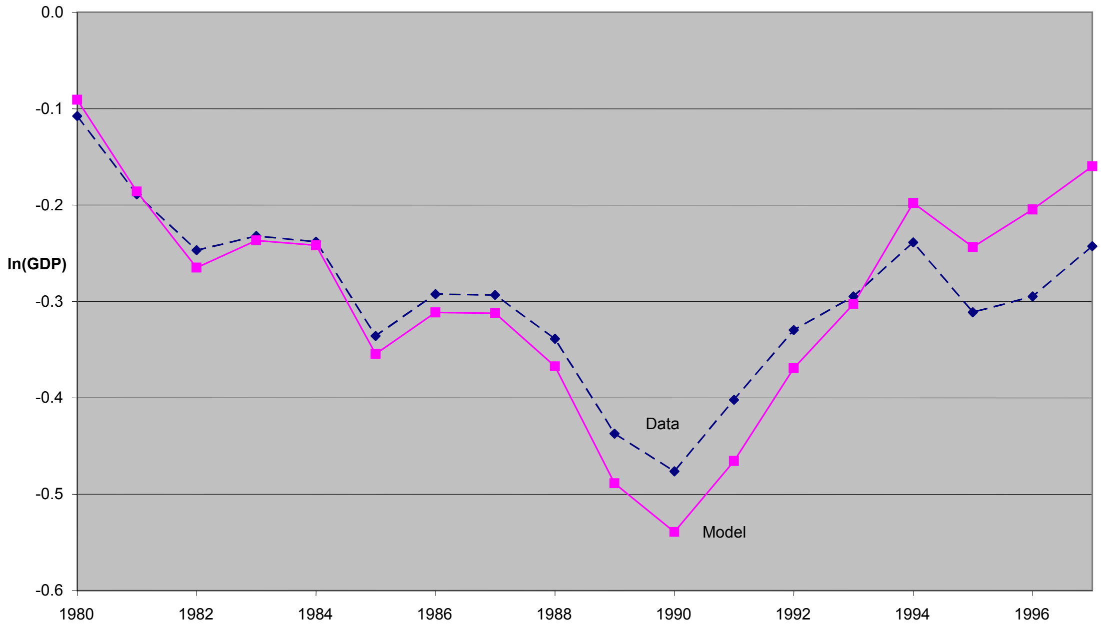
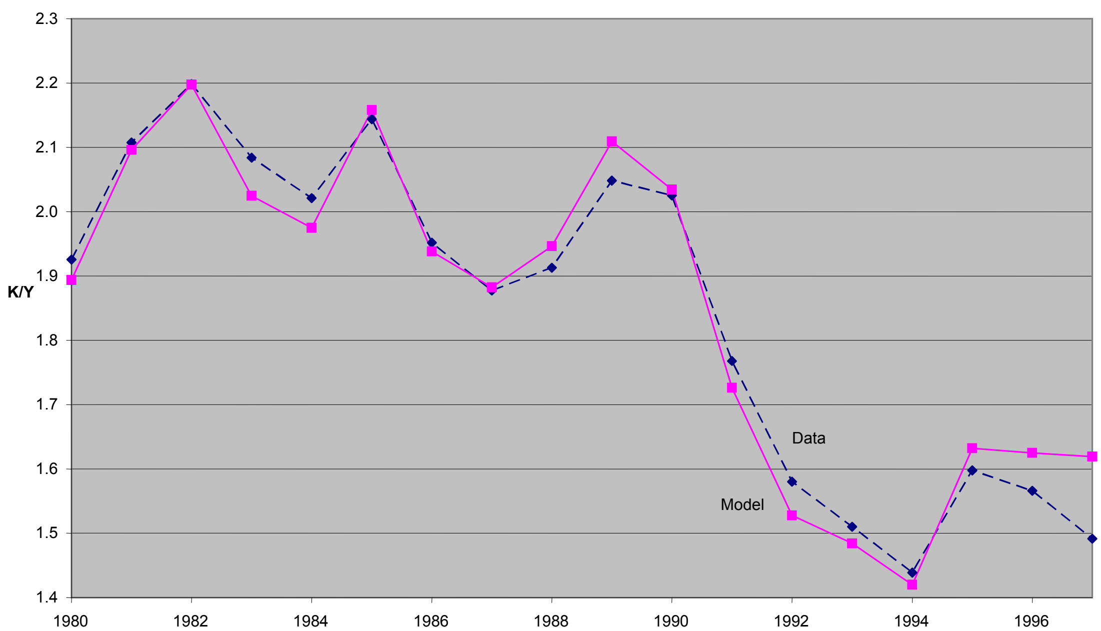


Figure 5

Capital–Output Ratio



APPENDIX A
Data Sources and Methodology

GDP and Population

The GDP series, in pesos of 1986, is from Meloni (1999).The working-age population data was obtained from CELADE (1985), applying geometric interpolation for the missing years.

Labor Input

The labor input is measured as the number of workers. For the period 1940–79, labor input is based on an employment series reported in Elías (1992). He used a series on wage earners' employment published by the Central Bank of Argentina for some of the years in the period and completed the missing years by interpolating labor force participation rates from population censuses run every 10 years.[7]

The procedure followed by Elías might understate the actual employment growth for years in which employment is estimated using labor force participation rates from census records. Labor force participation rates include both employed and unemployed workers. Unemployment rates experienced a continued decline between the year they began being measured (1963) and the last year of this period (1979). This underestimation of labor input may result in the mismeasurement of the Solow residuals for at least some of the years in the period 1963–79.

Employment data from 1980–91 are from the "Encuesta Permanente de Hogares" (Permanent Households Survey). The Ministry of Labor uses these surveys to compute, for each urban center, the fraction of the total number of individuals in all households interviewed that have reported some form of employment. It then applies the resulting proportion to the overall population of the corresponding district to arrive at an estimate of the total number of employed in each urban area. The estimation of the number of employed in areas not covered by the survey is accomplished by applying to the estimated total population in those areas the average of the employment coefficient just

[7] Elías' study contains only a brief account of the procedures used to construct this series. Some of the additional details just outlined were reported as documented in a written response by the author to a specific query we made in that regard.

described, weighted by the population of all urban centers other than the capital, the Buenos Aires metropolitan area.

One difficulty with these surveys is that it is not clear how well the households included in them represent the characteristics of the whole population.

Capital and Investment

We used the permanent inventory method to construct a capital stock series from investment figures from 1900 to 1997. The investment series, in 1986 prices, was kindly provided by Osvaldo Meloni.

The permanent inventory method requires applying different depreciation schemes to different types of assets. A typical distinction is between investment in machinery and equipment, nonresidential structures, and residential structures. Unfortunately, Argentina's national accounts do not report the last two concepts separately. A possible option to confront this difficulty is to ignore any distinction between the nonresidential and residential components of investment in structures.[8] An alternative followed here, based on standard practice by other researchers, was to assume that the nonresidential component is a fixed percentage of overall investment in structures. To that end, based on the considerations in Meloni (1999), we assume that 46 percent of that aggregate corresponds to nonresidential structures, with the remainder 54 percent allocated to residential structures.[9]

For the purpose of applying the permanent inventory method, we adopted depreciation parameters that combined the geometric and linear depreciation schemes in Hofman (1991) and Meloni (1999). In particular, we assumed that residential structures have a useful life of 50 years, nonresidential structures 40 years, and machinery and equipment 15 years.[10] As in a linear depreciation scheme, the assets lose any residual

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[8] This was implicitly the procedure adopted in Kydland and Zarazaga (2002a).

[9] Meloni, however, applied a substantially different percentage starting in 1991. Upon examination of the data, however, we concluded that such methodology, applied also in Kydland and Zarazaga (2002a), might result in the underestimation of the capital stock during the 1990s expansion. Accordingly, we applied the fixed 46 percentage all the way through instead.

[10] The capital stock estimates for the United States assume a linear depreciation scheme with useful life of the assets that are roughly in line with the ones assumed in this paper.

value after the last year of their lifetime. Under this assumption, the residual value of an asset at period t of productive capital installed n periods ago is given by $I_t(1-\delta)^n$, where δ is the depreciation rate, I_t the investment in the corresponding asset in period t, and $n \leq T$. The implicit depreciation rate δ was chosen so that the residual value of the relevant asset at the last year of its useful life is given by I_t/T, that is, to satisfy the equation $(1-\delta)^T = 1/T$. This method implied annual depreciation rates of 7.53 percent for investment in residential structures, 8.81 percent for investment in nonresidential structures, and 16.5 percent for machinery and equipment.

It is important to emphasize that implicit in the standard growth accounting method we used to measure TFP is the assumption that all factors of production, in particular capital input, are fully utilized. However, independent evidence suggests that capital utilization in Argentina declined substantially during the lost decade and recovered significantly in the subsequent expansion. Equivalently, capital input may have fallen during the lost decade more than our perpetual inventory method measures suggests. Likewise, it may have increased more than that measure during the subsequent expansion. Although there are no widely accepted measures of capital input adjusted for capital utilization, it is important to keep in mind that an unknown fraction of the large TFP shocks reported in Table 1 may be the result of changes in capital utilization missed by the perpetual inventory method.

APPENDIX B
Numerical Experiments Under Perfect Foresight

The results in the main body of the paper were derived under the assumption that agents form their expectations about the uncertain future in a rational way, in the usual sense that their subjective beliefs about the likelihood of future events coincides with the actual probability distribution of such events.

Many other papers in this volume, however, have adopted the alternative assumption that in making their decisions, the economic agents know the future with absolute certainty. In the spirit of facilitating comparisons across countries that inspires this volume, we report in this appendix the outcomes of the perfect foresight counterparts of the numerical experiments under rational expectations presented in the main body of the paper.

Unrealistic as it may be from a theoretical point of view, the perfect foresight assumption has the computationally appealing feature that the exact solution (to machine precision) for the equilibrium allocations of the neoclassical growth model can be computed quite easily. Indeed, by ex-ante attaching probability one to the exogenous shocks observed ex-post, the perfect foresight assumption expediently solves—at the cost of realism—the complex problem typically associated with the computation of mathematical expectations of endogenous variables in nonlinear problems. It is that complexity that often deters researchers from computing exact solutions to their models and leads them to resort instead to linear approximation techniques like the ones exploited in the main body of this chapter. In the case of the parsimonious neoclassical growth model used here, the perfect foresight assumption reduces the problem of computing the equilibrium allocations and decision rules to the relatively simple task of finding the deterministic saddle-path solution of that model with standard numerical methods.

To that end, we first reduced the analytical solution of the deterministic version of the neoclassical growth model in the main body of the paper to a system of two first-order nonlinear difference equations in capital and labor, with the initial condition for the capital stock, k_0, given by the level of capital stock actually observed at the beginning of 1980. We then exploited the well-known saddle-path properties of the solution to that deterministic system (for parameter values in the usual range dictated by theory) to actually compute it. Namely, there is one and only one value for l_0 (the fraction of time spent in market activities) that, in combination with the given initial capital stock k_0, guarantees that the solution to that dynamic system of nonlinear difference equations converges to the balanced-growth path. Initial values of l_0 different from the saddle-path solution l_0^* are associated either with explosive paths, along which the capital stock grows at rates progressively higher than that implied by the balanced-growth path, or with implosive ones, along which the initial capital is run down to zero. Exploiting this property, we first identify an initial value, l_0^e, for l_0 associated with an explosive path and another one, l_0^i, associated with an implosive path. The initial value saddle-path solution must lie somewhere in between, which calls naturally for the bisection method we used to find it. In implementing that method, we adapted to the utility function used in this paper an algorithm that Alpanda and Amaral developed to compute the perfect foresight experiments in the paper by Hayashi and Prescott in this same volume.[11]

The parameter values for our perfect foresight experiments were kept, of course, the same as in the experiments under rational expectations, except that we had to take into account that the algorithm for the perfect foresight experiments described above computes the exact (to machine precision) saddle-path of an economy with growth.[12] Accordingly, the depreciation rate, the interest rate, and the discount factor were set to the values implied by balanced-growth path relationships, rather than steady state relationships.[13]

[11] We are thankful to Sami Alpanda and Pedro Amaral for having facilitated us the algorithm they developed in Matlab code. The adaptation used for this appendix is available from us upon request.

[12] Recall that the algorithm for the rational expectations experiments approximated the solution around the steady state, that is, for the economy *without* growth, following the calibration procedure suggested by Hansen in the paper mentioned in the main body of the paper.

[13] More specifically, $\delta = x/k + (1+\eta)(1+\gamma) - 1$ = 0.087, $i = \theta(y/k) - \delta$ = 0.113, $\beta = (1+\gamma)^{1-\alpha(1-\sigma)}/(1+i)$ = 0.911, where i is the real interest rate.

Figures B.2, B.3, B.4, and B.5 are the perfect foresight counterparts of the figures labeled with the same numerals in the text. As in text, the data and model predictions have been detrended by the applicable balanced-growth rates.

Comparison of Figures 4 and B.4 readily alerts that the results of the numerical experiments under perfect foresight are different from the stochastic version reported in the main body of the paper. That discrepancy can be traced to a large extent to the capital stock in Figure B.2. While the stochastic version of the model predicts the decline of the capital stock during the lost decade quite accurately, the perfect foresight version seriously underestimates that decline. To be more specific, according to the perfect foresight version, the (detrended) capital stock should have been 15 percent lower in 1990, at the end of the lost decade, than it was in 1980—half the decline predicted by the rational expectations version. By contrast, the perfect foresight version overestimates the decline of labor input over that same period by twice as much as it does the rational expectations counterpart of the same experiment.

Given the non-negligible quantitative differences in the outcomes of the numerical experiments under the alternative perfect foresight and rational expectations assumptions, it is important to gain some intuition into their possible sources. To that effect, imagine at the onset of the Argentine depression two representative consumers that perfectly anticipated the unlikely streak of adverse TFP shocks that would hit the economy over the next decade or so. However, assume that only one of them perfectly anticipated as well the equally unlikely sequence of sizable positive TFP shocks that would hit the economy in the subsequent expansion. (Recall that according to Table 1, those shocks implied annual average productivity gains of around 4 percent over that expansion!)[14] For the sake of the argument, we'll loosely refer to this last imaginary consumer as the consumer endowed with complete perfect foresight. The other imaginary observer, loosely referred to as the consumer with partial perfect foresight, expects productivity gains over the expansion to be in the order of magnitude historically observed, that is, 1.03 percent a year.

Theory suggests that in the face of a streak of adverse shocks like the ones observed in the lost decade in Argentina, both consumers will smooth their consumption

[14] Computed by applying to the corresponding TFP factor in Table 1 the formula in Footnote 3.

over that period by drawing down their savings, that is, the capital stock. However, the consumer with complete perfect foresight, aware that holding on to his capital will allow him to exploit the unusually high rates of return on that factor he believes are coming for sure in the subsequent recovery, will not want to deplete his savings (or capital stock) as much as the imaginary consumer with partial perfect foresight, who expects just normal productivity shocks and, thus, more moderate rates of return on his capital over that subsequent decade.

Figures 2 and B.2 bear well the intuition above. According to those figures, both of our imaginary consumers ran down their savings during the lost decade—but less so the consumer of the perfect foresight economy represented in Figure B.2, because he knew in advance that his relatively more thrifty behavior would be heftily rewarded in the subsequent recovery in the form of unusually high rental prices of capital. By contrast, our imaginary inhabitant of the rational expectations economy, represented in Figure 2, with forecasting capabilities closer to what ought to be expected from humans, attached a very low probability to the long streak of unusually high TFP shocks actually observed in the subsequent recovery. He expected instead that rental prices for capital over that period would be closer to the historical average. Accordingly, he didn't mind running down his savings (capital stock) over the lost decade at a faster rate than his perfect foresight counterpart of Figure B.2.

The intuition behind the reported discrepancies between the perfect foresight and rational expectations versions of otherwise identical economies invites caution about interpreting the outcomes from numerical experiments under perfect foresight as a fair representation of the actual dynamics of the capital stock and other variables directly related to it (such as GDP, interest rates, etc.) in economies subject to a great deal of uncertainty. Such significant discrepancies are more likely to emerge in economies with wild swings in the exogenous shocks than in economies with less volatile shocks. It is for the former group of countries (to which, per the evidence in Table 1, Argentina seems to belong) that the perfect foresight assumption might be a particularly bad approximation to the way in which agents actually form their expectations about the future and therefore miss, by a potentially wide margin, the dynamics of labor and savings decisions along pronounced boom and bust cycles.

FIGURE B.2
PERFECT FORESIGHT
Capital Stock

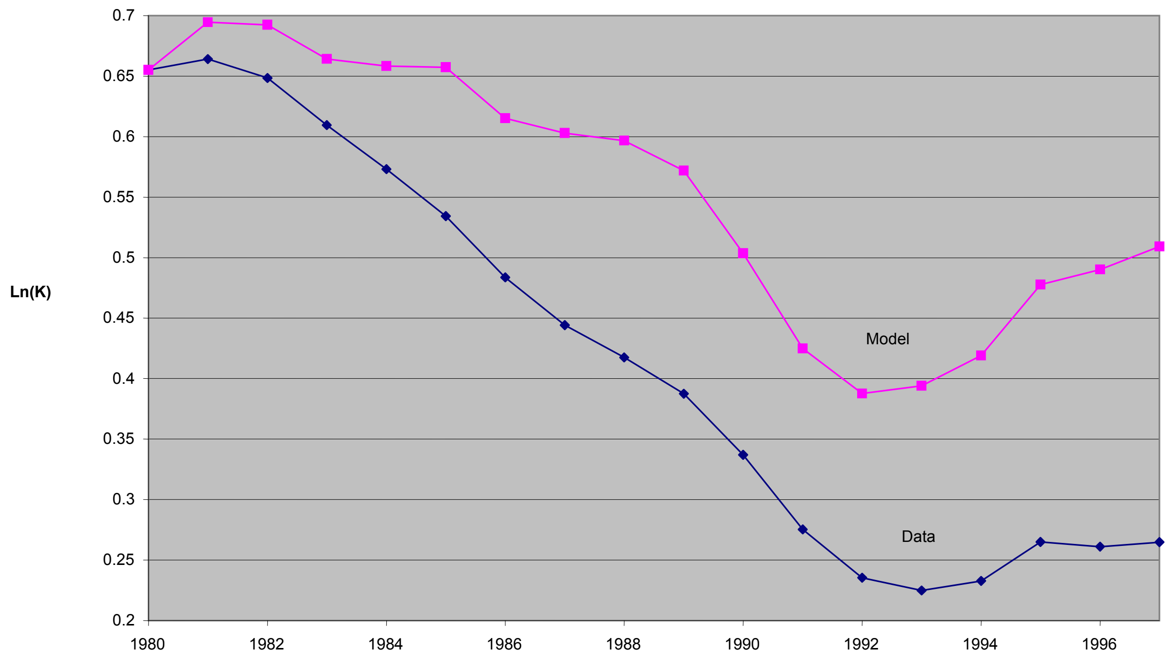

FIGURE B.3

PERFECT FORESIGHT
Labor Input

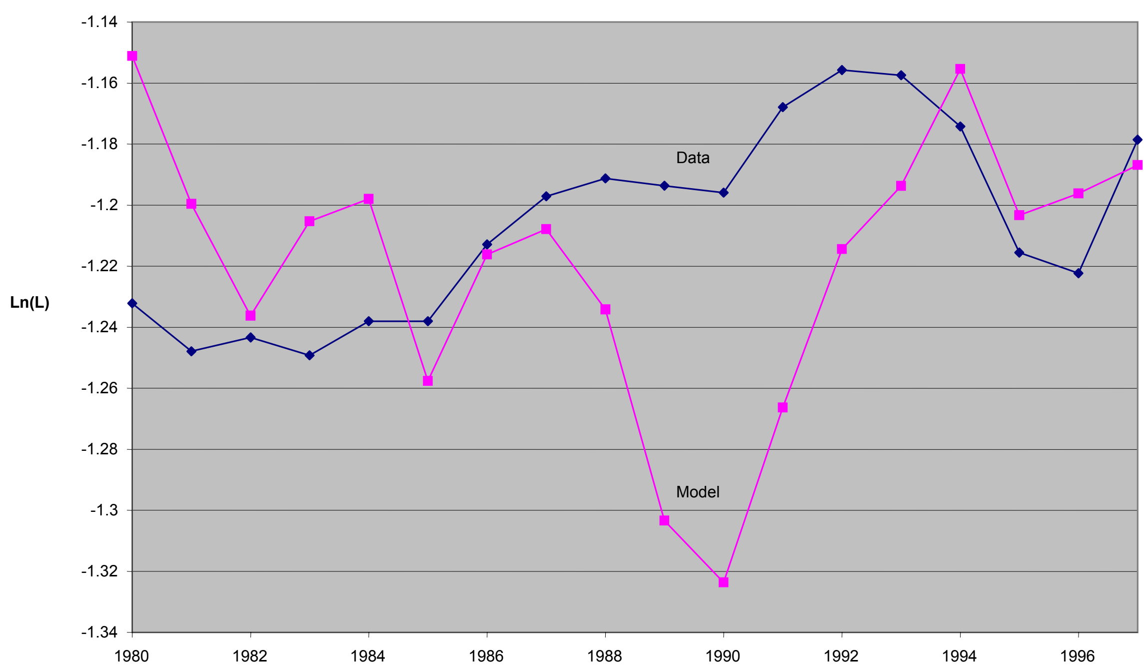

FIGURE B.4
PERFECT FORESIGHT
GDP per Working-Age Person

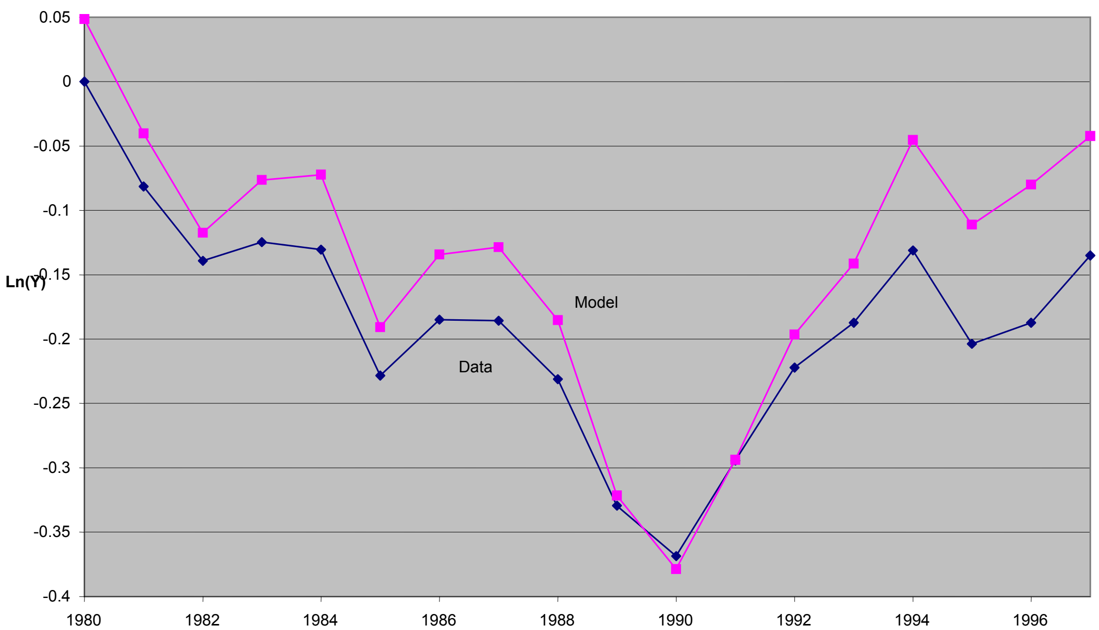

FIGURE B.5
PERFECT FORESIGHT
Capital–Output Ratio